FOCUS ON ORTHOTICS

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Much of the research and education activities at New York University have traditionally been associated with prosthetics—the evaluation of artificial limb components, fabrication techniques, treatment procedures for amputees, as well as the conduct of courses in prosthetics for limbfitters, therapists, physicians and rehabilitation counselors. Our concentration on prosthetics developments in recent years has overshadowed our equal interest in the field of orthotics—an interest reaching back before 1946 when our first report in this field was published.[1] Since that time we have remained interested but relatively inactive bystanders, participating in meetings on bracing problems and even advancing proposals from time to time for systematic research in bracing.[2]

Recently, however, many orthotists have indicated their interest in and have emphasized the desirability of research programs and university courses in orthotics comparable to those available in prosthetics. This view seemed essentially sound and reasonable considering the generally acknowledged value of current research and education activities in prosthetics. However there are important differences between the two fields. Prosthetics research has been centered on specific techniques—studies have been aimed at the development or evaluation of such devices or techniques as the patellar tendon bearing below-knee and the quadrilateral above-knee sockets and

[1] *Preliminary Investigation with Respect to Leg Braces*, Research Division Project No. 80, College of Engineering, New York University.

[2] Sidney Fishman, *Proposals for Research in Bracing*, First Amputee Research Conference, December 1958, University of California at Berkeley, San Francisco, 1959.

plastic laminate arms; schools have offered courses to teach the related fabrication techniques and treatment procedures.

In orthotics, research activities are not yet coordinated in a cooperative development and test program through which new techniques and devices can be developed, evaluated, and refined for teaching in schools. The field of orthotics encompasses a wider range of disabilities than prosthetics with greater numbers and more intricate varieties of pathology. It seems clear that more information is needed before any concrete steps in orthotics research or education can be taken.

Our initial approach to this problem was an attempt to develop an up-to-date overview of the field which would be realistically related to the status of the art today. One of the simplest and certainly the most valuable way to do this was to discuss the field with experienced orthotists.

Accordingly, in cooperation with the American Orthotics and Prosthetics Association (then the Orthopedic Appliance and Limb Manufacturers Association), twelve of the leading brace makers from different parts of the country were invited to a 6-day conference sponsored by the New York University Post-Graduate Medical School in August 1958. The purpose was to explore various aspects of modern orthotic practice: to define standards, generally agreed-upon practices, and thinking in orthotics today, and to explore those areas in which opinions and practices differ in order to identify specific problems which might be amenable to research.

As a result of these deliberations, it became increasingly clear that:

a. there are no serious disagreements among orthotists concerning a large body of orthotic theory and practice; although individual techniques may vary, there is relative unanimity of opinion about the rationale and general procedures for the construction and fitting of many devices.

b. there are also clearcut issues and differences of opinion in certain areas; the fitting and fabrication of braces is quite variable with respect to specific techniques, selection of components, and expected outcomes.

In presenting this picture of general agreement in certain areas, and differences of opinion in others, the Conference raised two fundamental questions:

a. Could the questions and differences of opinion which arose be formulated as problems for investigation in a research program?

To answer this question the discussions of each issue were carefully examined to identify those problems whose solution might best be approached by research methods. For example, if a matter of esthetic judgment, economics, or equally valid but opposing opinions was involved, the issue would probably not be a suitable subject for objective analysis. On the other hand, matters of comfort, fit, alignment and function involving strength of materials, function of components, and the reactions and performances of patients do lend themselves to scientific study.

b. Do the scope and significance of the body of orthotic knowledge and practice upon which leading orthotists generally agree warrant the organization of a pilot course to present this material as "standard practice"?

In this connection it was necessary to consider that the entire group participating in the conference were highly experienced and skilled orthotists who were able to find agreement among themselves on specific practices. They may not, therefore, be the audience for whom a course of instruction on these standard practices would be most valuable. Whether such a course

could benefit a great majority of practicing orthotists in this country is a decisive factor in this question.

On the basis of discussions with physicians, orthotists and others in the field, the answers to both questions were clearly affirmative. Accordingly at New York University we undertook:

1. preliminary steps to develop a research program to provide a systematic, practically-oriented attack on the issues
2. the organization of material for a "pilot course" in bracing.

Orthotics Research

Those contemplating research in a broad and complex field must decide which of two general approaches to take. A fundamental approach is generally indicated when specific problems in the field are difficult to identify or when little urgency exists for early results. The investigator is not usually concerned with the evaluation or improvement of existing conditions; he simply studies certain basic phenomena without regard to the final application or use to which the result may be put. In bracing, however, there are many obvious problems whose solution may have immediate and direct application to current practice in orthotics. In view of this we selected a practical orientation for our initial studies.

During the Conference many more issues were identified than could be investigated in a beginning research program. This made it necessary to choose the questions which were most significant and which were also most amenable to study with existing resources. A series of problems was finally selected for investigation on the basis of significance to a group of orthotists and their clinical practicality. Procedures for the methodical exploration of each problem were developed.

At the present time, support for this work comes from both New York University and the Easter Seal Research Foundation. It provides for the services of a staff which includes a project director, two full-time engineers, as well as the consulting services of a kinesiologist with extensive research experience in normal and pathologic locomotion, and a certified orthotist. This staff is organized as a special project in the Research Division, College of Engineering, New York University, with quarters at 252 Seventh Avenue, New York City.

Our immediate goals in this program are the solution or clarification of eight specific practical problems. We do not anticipate the complete solution of all these problems within the period and resources presently available. Some of the questions appear relatively simple and may well yield satisfactory conclusions; others are more complex and our initial exploratory efforts may serve only to clarify the main issue and indicate possible methods of solution. Specifically we are developing procedures and instruments to investigate the problems described below.

In common paralysis or weakness of the plantar flexors, standing balance is difficult to maintain, particularly among paraplegics who are fitted bilaterally. Anterior stops or spring loaded mechanisms are commonly used to control the forces acting to unbalance the body. These devices are frequently inadequate, requiring patients to depend on additional supports such as canes or crutches. Consequently, we plan to study the relative effectiveness of anterior stops and/or spring loaded devices as methods of maintaining anterio-posterior stability when standing upright.

The walking cycle is usually studied in two phases—swing and stance. For the brace wearer, the most significant problems develop during the stance phase since it is at that time that the knee is least stable. At heel strike, the dorsiflexor muscles normally resist the torque developed at the

ankle. In the brace wearer with paralyzed or paretic dorsiflexors, the torque is transmitted by the stop of the brace through the uprights and calf band to the leg, tending to flex the knee. As pathologic weakness of the knee extensors is common among short leg brace wearers, the tendency toward knee instability at heel strike is increased. In controlling ankle motion, therefore, the problem of knee instability may often be aggravated. To determine how this sequence influences the mechanics of knee motion and the gait pattern, we propose to investivate the effect of a posterior 90 degree stop on knee stability at the time of heel strike.

Knee hyperextension during mid-stance and push-off is also a common problem among short leg brace wearers. It is often caused by weakness of the knee extensors or flexors, or plantar flexion contracture. The effectiveness with which the calf band resists hyperextension is dependent on its vertical location and configuration. We shall attempt to determine the optimal vertical position of calf bands in the short leg appliance for resisting the forces acting to hyperextend the knee during stance.

In common practice braces are toed-out at approximately 7½ degrees. As studies have indicated that toe-out in the normal human being during stance ranges between 5 and 15 degrees, the effect of brace toe-out on body stability in the stance phase of gait will be studied.

At the present time there is no reliable method of objectively measuring the amount of body weight supported through an appliance. Present determinations are based on patients' reactions which may vary with an individual's tolerance to pain or discomfort. Objective methods are needed to indicate total load-bearing by the appliance and to permit graded variations in the load supported. As a first step, we plan to measure the extent to which commonly used weight-bearing devices (Thomas Ring, Quadrilateral Socket and bands) actually bear the loads for which they have been designed.

Deficiencies of the lateral collateral structures of the knee during mid-stance tend to cause varum deformity. The medial upright of a long leg appliance is designed to counteract the tendency toward genu varum. Since the point at which the support is applied is the critical feature, the effect of height of the uprights on the medio-lateral knee stability in stance will be evaluated.

Long leg brace components, i.e., joints, bands, and "knee caps" are usually fitted to provide optimal stability, function, and comfort during gait and stance. However, when the patient sits, relative motion frequently occurs between brace components and the limb (as between orthotic and anatomic knee axes), resulting in excessive pressures and discomfort. Although the "knee cap" serves the primary function of preventing the knee from buckling when the patient stands or walks, it also exerts strong pressure on the patella when he sits. Similarly, the mid-thigh and calf bands exert extensive pressures on the affected limb when the patient is sitting. It is important therefore to learn the extent of variability possible in the alignment of anatomic and mechanical knee joint axes without causing excessive relative motion and consequent discomfort or additional functional limitations. The need for and the role of thigh bands, knee caps and calf bands will also be investigated.

During these studies the status and performance of a series of brace wearing patients will be evaluated. The adjustment, alignment and specific components of their braces will be systematically altered and the resultant effects will be evaluated. Our assessment will be based upon five general factors:

Comfort
Ability to stand, walk, sit
Quality of walking
Energy required to walk
Durability and maintenance requirements

In addition to the subjective reactions of the test patients, both previously used engineering methods and some more recently developed techniques will be employed. Kinematic and kinetic studies will be undertaken to provide objective biomechanical analyses of performance. Measures of energy expenditure obtained by physiological methods will also be used in these evaluations. As an additional aid, we have designed an instrumented component which, when installed in a brace, will permit us to measure some of the forces acting through it.

Individually, the methods by which these problems will be attacked are quite conventional. Combining them into a battery promises to give us a systematic and comprehensive research tool which may also be applicable to the evaluation of orthotic devices in general. As these studies progress, new insights provided by the data will be made available for early dissemination in the orthotics courses which are also being planned.

Orthotics Education

It became clear during the Conference that there exists a significant area of orthotic knowledge and practice in which the rationale and procedures for fitting and fabrication are generally accepted. Whether it would be of service to the field to organize and present this material in formal university courses at this time is less clear despite many opinions supporting such a step. Every knowledgeable person in the field with whom the matter has been discussed has expressed the opinion that a systematic presentation of generally approved practices would be a significant service. Also emphasized was the value to orthotists of including in formal courses, information concerning pathology and prescription rationale. Notwithstanding the enthusiasm for formal orthotics education, a great deal more must be known before a series of sound regularly scheduled courses can be offered. It is of primary importance to assess *the need* for disseminating to the field at large the materials which constitute generally accepted, standard practices among advanced orthotists. It is also necessary to define the most valuable contents for a course of this nature and to give the material proper emphasis. To obtain this information we are planning a "pilot" course scheduled for the early part of 1961. This initial offering will be devoted to standard treatment approaches to disabilities of the lower extremity which warrant the prescription of short and long leg braces, including certain major variations of these basic types. Highly experienced orthotists whose background will enable them to help us evaluate this "trial balloon" critically and constructively will be invited.

If the pilot course experience should indicate the desirability of continuing efforts in orthotics education, we can anticipate that a regular series of orthotics courses will be subsequently offered. Eventually these courses may be expanded by adding sections, if warranted, for physicians and therapists as well as orthotists in the pattern already established in prosthetics courses.

Also to be considered is the four year college curriculum leading to a bachelor's degree in prosthetics and orthotics being offered at the New York University School of Education beginning in the Fall of 1960. Little specialization is scheduled for the first two years, with most of the professional content to be taught in the last two years. No great problems are anticipated in adapting the currently used methods and materials of prosthetics educa-

tion for use in the professional curriculum. But at the present time we have no comparable body of materials in orthotics. Our pilot efforts may therefore fulfill the additional need of producing instructional materials which would also be appropriate for the four-year professional course.

At the present time a manual of instruction is being prepared. Included are basic materials necessary for the pilot course: anatomy, physiology, biomechanics, and prescription indications. In addition the following topics, which were discussed during the Conference, will provide a basis for the selection of orthotic fabrication teaching materials:

A. *Materials*
1. Basic materials
2. Physical characteristics
3. Problems of maintenance and durability
4. Basis of selection
5. Metals and their applications in orthotics
6. Leathers and plastics and their applications in orthotics

B. *Components*
1. Shoes
2. Shoe attachments
3. Joints
4. "Stops"
5. Locks
6. Bands
7. Leather parts and accessories

C. *Types of Lower Extremity Orthotic Devices*
1. Ankle and leg
2. Knee
3. Ankle and knee
4. Hip
5. Hip, knee and ankle

D. *Problem Analysis*
Selection of the appropriate device, materials and components:
1. Ankle and leg disabilities
2. Knee disabilities
3. Ankle and knee disabilities
4. Hip disabilities
5. Disabilities involving ankle, knee and hip

E. *Alignment*
1. Joint placement
2. Placement of uprights, bands and cuffs

F. *Fabrication*
1. Principles and practices of fabrication
2. Use of hand forged and prefabricated parts
3. Use of special tools in fabrication

G. *Fitting*
Fitting principles and practices:
1. Measurements
2. Initial fitting
3. Final fitting

In summary, we are planning both research and education activities in the field of orthotics, with limited initial goals in each of these areas. A beginning has been made in developing a research program to study significant bracing problems. While many such issues have been defined, our initial effort will be focused on questions having immediate clinical application and those which are of technical importance to orthotists. We plan to improve present research techniques and to develop others as needed in order to achieve a sound, objective and comprehensive evaluation method. The results of these studies will be made available to the field through periodic and special reports and through a series of short-term regularly scheduled courses.

The forerunner of these courses will be a "pilot" offering on lower extremity bracing early in 1961. Highly experienced orthotists will be invited to attend the first course to help us evaluate subsequent educational

needs in bracing. We trust that these two steps in research and education will mark the beginning of a concerted effort to bring orthotics on par with prosthetics by providing a sound basis in biomechanics, scientific prescription rationale, reliable evaluation techniques and a professional educational system.

THE PROBLEM OF PREDICTING SUCCESS IN PROSTHETIC REHABILITATION

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Every sincere practitioner in the field of prosthetics has moments of deep satisfaction when his services fulfill a human need and are favorably received. When an amputee is successfully fitted, memories of difficult problems dissolve, periods of anxiety-soaked stress are transformed in the mind and acquire a halo of adventure. A successful conclusion to a difficult case invigorates the clinic personnel, but failure shakes the egos of all who are involved in the rehabilitation process.

Should his counsel fail, the psychologist, who is really a professional parent-image, feels the pangs of rejection. Should the amputee's stump be on the verge of collapse under prosthetic pressure, the physician feels his spirits falling with it. When gait-training deteriorates into aimless shuffling, punctuated by sighs of pain or discomfort, the physical therapist experiences the pangs of a Second Lieutenant leading a green patrol into a maze of booby-traps. But by far the most severe sufferer, when failure occurs, is the prosthetist—for it is the prosthesis, in the construction of which he has spent such great effort, which is regarded as an object of scorn, often unjustifiably. We say "unjustifiably" advisedly. Some failures in prosthetic and vocational rehabilitation stem from errors in professional judgment. Many of the failures, however, are really traceable to the personality difficulties of the amputee clients. For it is well-known that certain amputees "just cannot be fitted," irrespective of the merits of the prosthesis or prosthetist. The